

Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) EP 1 014 296 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.06.2000 Bulletin 2000/26

(51) Int. Cl.⁷: G06K 15/02

(21) Application number: 99125217.2

(22) Date of filing: 17.12.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• Butterfield, Paul M.
Fairport, NY 14450 (US)
• Robinson, David C.
Perfield, NY 14526 (US)

(30) Priority: 23.12.1998 US 220051

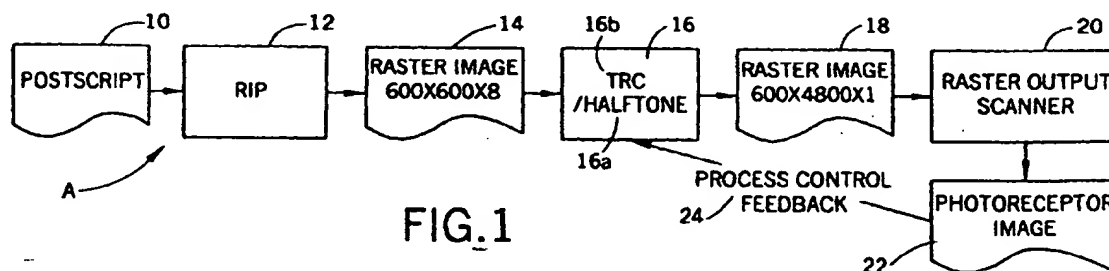
(74) Representative:
Grünecker, Kinkeldey,
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(71) Applicant: Xerox Corporation
Rochester, New York 14644 (US)

(54) Adjusting halftone patterns to maintain print quality

(57) A method and apparatus to maintain constant tone reproduction on a printed output over time. This is accomplished by performing template matching on a halftoned binary image prior to sending the binary image to a Raster Image Processor (ROS). The tem-

plate matching operation selectively replaces bit patterns in the binary image with template bit patterns, based on a detected xerographic density.



Description

[0001] In general, digital image output terminals (e.g. printers) are capable of creating spots within an area with a predetermined resolution (dots per unit area). In scanners, a single "spot" describes a multi-bit density response. Typically, input scanners may acquire density information at 256 levels of gray to describe a spot or pixel. By contrast, output terminals generally have two or another relatively small number of levels to reproduce image information.

[0002] In printing systems maintaining stability and accuracy as to the amount of a marking material (e.g. toner or ink) being applied to a print surface is a major concern. Specifically it is known that due to varying conditions the amount of marking material (e.g. cyan, magenta, yellow and black toner or ink) will fluctuate from a predetermined value. For example, humidity, toner or ink age, machine calibration, toner or ink quality can all cause the amount of marking material applied to a print surface to vary.

[0003] Therefore, in color and black and white copiers or printers, a common technique for monitoring the quality of documents is to artificially create test patches of predetermined desired densities. The actual density of the toner of the test patches can then be optically measured to determine the effectiveness of the printing process in placing this printing material on the print sheet.

[0004] In the case of xerographic devices, the surface that is typically of most interest in determining the density of printing material is the charge-retentive surface or photoreceptor, on which the electrostatic latent image is formed and subsequently, developed by causing toner particles to adhere to areas that are charged in a particular way. In such a case, the density detector for determining the density of toner on the test patch, which is often referred to as a "densitometer", is disposed along the path of the photoreceptor directly downstream of the development unit. There is typically a routine within the operating system of the printer to periodically create test patches of a desired density at predetermined locations on the photoreceptor by deliberately causing the exposure system to charge or discharge, as necessary, the surface at a predetermined location.

[0005] The test patches are moved past the development unit and the toner particles within the development unit are caused to electrostatically adhere to the test patches. The denser the toner on the test patches, the darker the test patches will appear in optical testing. The developed test patches are moved past a density detector disposed along the path of the photoreceptor, and the light absorption of the test patch is tested; the more light that is absorbed by the test patch, the denser the toner on the test patch. Xerographic test patches are traditionally printed in the inter-document zones on the photoreceptor. They are used to measure the deposition of toner on paper to measure and control the toner

reproduction curve (TRC). A common method of process control involves scheduling solid area, uniform half-tones or background in test patches. High quality printers will often contain many test patches.

[0006] Depiction of a process whereby a printing machine maintains output print density is illustrated in Figure 1. Shown is an image path A for a printing machine where a page description module (which implements a page description language (PDL) such as, but not limited to, PostScript) 10 forwards image information to Raster Image Processor module (RIP) 12. The RIP generates a rasterized image (in this example, a 600 x 600 x 8 image) 14. Through this procedure a contone image (e.g. having cyan, magenta, yellow and black) is described in a gray level format. Contone Rendering Module (CRM) 16 receives rasterized image 14 and performs a halftoning operation 16a of the rasterized image 14 in accordance with a predetermined tone reproduction curve (TRC) 16b. The CRM 16 then generates a rasterized binary (bitmapped) image having a high addressability factor (e.g. 600 x 4,800 x 1) 18. This binary image is provided to Raster Output Scanner (ROS) 20 which in turn generates photoreceptor image 22. Using photoreceptor image 22, normal known xerographic operations are undertaken for the generation of a color print.

[0007] Consistent tone reproduction is a high priority in color production markets. Even slight (e.g. $2\Delta E_{cmc}$) color changes within a job can be objectionable to a customer. Within the architecture described in Figure 1, constant tone reproduction for printed outputs over time is maintained by feeding real-time (inter-document zone) xerographic density information to CRM 16 of the print engine. CRM 16 applies an appropriate TRC 16b to each contone image and then the image is halftoned to a binary high-addressable image space understood by ROS 20.

[0008] Data concerning the xerographic density of patches on photoreceptor image 22 are provided to the CRM 16 by process control feedback 24. In order to maintain a stable printing operation despite the fact that the print engine output may be varying, the tone reproduction curve (TRC) 16b is applied immediately before the halftoner operation 16a. Thus, if the signal from process control feedback 24 indicates the xerographic density values are off a nominal amount, TRC 16b is changed in front of halftoner operation 16a in order to provide desired print outputs. For example, if the printer is determined to be printing overly high yellow amounts of toner, the tone reproduction curve will be adjusted slightly down so that the yellow toner amount requested is decreased, thereby maintaining a stable printing output.

[0009] However, under the foregoing process there exists a need to be able to update TRC 16b on the print engine CRM 16 due to the possibility of a customer job not completely printing before the xerographic density state has changed. In a machine implementing image

path A or B, if the xerographic density state changes during the time a job is printing, this system which undertakes an original halftoning process at RIP module 12, is forced to re-RIP the job in progress. The re-RIP would be done with the new xerographic density information. Due to this productivity impact, as well as the cost involved in providing a machine having such capabilities, quality benefits provided by a RIP that halftones is not fully attained.

[0010] A further drawback of the foregoing system is that the halftone operation must be accomplished in a real-time operation, which in turn requires implementation of halftoner 16a in CRM 16 which increases the cost of such a printing machine.

[0011] Therefore, it has been determined desirable to provide a method and apparatus that effectively adjusts the ROS image TRC after the image is in a binary printable space, and where the real-time adjustment may be made in reaction to a change in the xerographic density state.

[0012] The present invention describes an apparatus for maintaining image quality in a printing system. The apparatus includes a process state detector which detects a process state of the printing system. A template matching device is configured to receive data from the process state detector regarding the process state of the printing system. An image scanner is provided for scanning a binary bit-mapped image, and a template storage stores a plurality of predefined templates of bit-mapped patterns. The data from the process state detector is used to determine whether at least a portion of the binary bit-map image is to be replaced by at least one of the plurality of predefined templates through operation of the template matching device.

[0013] Further, data from the process state detector is collected based on analog signals, and the binary bit-mapped image is configured in accordance with digital signals, such that output analog signals of the printing system are used to alter the binary bit-mapped digital image.

[0014] Additionally, the density detector is configured to separately detect each color of the marking material, and each separately detected density value is used in separate scanning operations for each color.

Figure 1 is a block diagram of an image path incorporated into an existing printing machine;

Figure 2 is an alternative image path to the image path shown in Figure 1;

Figure 3 is an image path of a printing machine incorporating the concepts of the present invention;

Figure 4 is an illustrative description of an apparatus for adjusting the input binary image halftone dots using the template-matching operation of the present invention controlled by the print engine xerographic density information;

Figure 5 is a flow chart depicting steps involved in adjusting the input binary image halftone dots using

template-matching processing in accordance with a device as shown in Figure 4;

Figure 6 is a flow chart setting forth alternative steps for adjusting the input binary image halftone dots using template-matching processing in accordance with a device as shown in Figure 4.

Figures 7 and 8 illustrate template storage configurations in accordance with the teachings of Figures 5 and 6;

Figure 9 diagrammatically illustrates substitution of a bit pattern detected during the scanning operation and a template bit pattern being substituted therefore; and

Figure 10 illustrates a configuration for refined bit density detection which may be used in refined template-matching techniques.

[0015] With attention to Figure 2, an image path B is depicted for a printing machine which eliminates the generation of rasterized image (e.g. 600 x 600 x 8) 14 and Contone Rendering Module (CRM) 16 of image path A, illustrated in Figure 1. While a printing machine implementing image path A of Figure 1 provides robust process control, it is achieved at high economic and productivity costs, and receives no quality benefit from high resolution RIP 12. On the other hand, image path B which employs page description language module 10', high resolution RIP (which incorporates halftoning operations) 12', binary raster image (e.g. 600 x 4,800 x 1) 18', and Raster Output Scanner (ROS) 20' to generate photoreceptor image 22', allows for attainment of quality benefits from use of high resolution RIP 12', and is a more economical printing machine than a machine constructed in accordance with image path A. However, a drawback of a machine using image path B is that there is no process control for maintaining stability of printing output over time. Therefore there is a high likelihood that the quality of the prints for such a printing machine, as shown in Figure 4, will not be acceptable to a user over an extended period of time.

[0016] Turning more specifically to the present invention, Figure 3 illustrates an image path C for a printing machine incorporating the concepts of the present invention. Similar to Figures 1 and 4, a page description module 10" having image data supplies the image data to a RIP module (which incorporates halftoning operations) 12". However unlike image path A (but similar to image path B of Figure 4) contone raster image (e.g. 600 x 600 x 8) 14 and contone rendering module (CRM) 16 are not required. Rather, RIP module 12" transforms the image information directly into a binary halftoned raster image (e.g. 600 x 4,800 x 1) 18". Thereafter, and distinguished from previous systems, a template matching module 40 is provided between binary halftoned image 18" and ROS 20". The ROS 20" uses bit patterns supplied from template matching module 40 to generate photoreceptor image 22", which is in turn used in xerographic operations to produce a

requested print.

[0017] Process control feedback 42 of image path C is a detector system used to detect xerographic density information regarding test patches formed on the photoreceptor. This information is transmitted to template matching module 40.

[0018] Thus, unlike Figure 1 where the image is processed by RIP 12, to contone image 14, the image in Figure 3 is RIPed directly to binary image 18. Since the raster image processing by RIP module 12, as opposed to 16b, does not need to be accomplished in real-time, a less expensive halftoning algorithm may be implemented thereby lowering the cost of the printing machine.

[0019] Turning to Figure 4, an illustrative description of the present invention is provided, in conjunction with the flowchart of Figure 5. In particular, test patches 90a-90n are shown in an inter-document zone following Image 1 on photoreceptor 92. A process state detector arrangement 94 detects the density of test patches 90a-90n and sends this status information to template matching block 96 of template matching module 40. This information may be sent continuously to template matching module 40 or it may be sent at predetermined intervals. The above noted test patches being formed of a marking material such as toner or ink or by another known technique.

[0020] Template matching module 40 is configured to receive binary raster image 18", and also includes bitmap scanner arrangement 98, and template storage 100. It is to be appreciated that while the above-described elements are shown in block diagram formats, specific configurations of these elements are known in the art, and a variety are taught by material which has been incorporated herein by reference. It is also to be appreciated that while the foregoing elements are depicted as existing within template matching module 40, they may exist physically distant from module 40 but nevertheless can be used in the process described herein. For example, template storage 100, while shown in template matching module 40, may in fact exist in a memory location separate from module 40.

[0021] It is to be appreciated that process state detector arrangement 94, may be any device which detects and/or interprets density when defined as the negative log of reflectance, or when density is defined as a visually significant imaging material per unit area. For example, process state detector arrangement 94, may be a density detector, an L* detector or any other direct or indirect indicator of a process state including but not limited to photoreceptor voltage, or ambient humidity. Further, while the foregoing has been described in connection with the detection of color patches on a photoreceptor, the patches may be monochrome, and the patches (or other shape) may be located on a document including but not limited to paper.

[0022] Image 2, shown by dashed lines, is the

image which will be produced by the processing to be discussed. Thus, the knowledge obtained from the test patches 90a-90n on photoreceptor 92 is applied to the development of Image 2 shown by dashed lines.

[0023] Turning to Figure 7, a basic outline for one embodiment of an operation occurring within template matching module 40 is set forth. Initially, the measured xerographic density value from the density detector system 94 is acquired (110). A determination is then made as to whether the xerographic density value is within a pre-determined nominal bit density range (112). When within the nominal bit density range, bitmap scanner arrangement 98 begins scanning the received binary raster image 18" (114). If the actual xerographic density value is within the nominal range, information obtained by the scanning process is ignored (116). A determination is then made as to whether the scanning process is completed (118). If not completed the system moves back to block (114) and process steps 114-118 are repeated. If the scanning is completed the process is ended and the unaltered bit-mapped image is forwarded for raster output scanning (e.g. ROS 20") (120). It is to be appreciated that in alternative embodiments the scanning process may not even be started as long as the detected xerographic density value is within the normal range or greater than $n+7$, (where in this example each increment can be designed to represent .1 density units) and the binary raster image may be sent directly to ROS 20".

[0024] When in step (112) the xerographic density value is found not to be within the nominal range, a determination is made as to how far it is from the nominal range (e.g. is the actual values within a selected range: $n+2$ to $n+4$; $n+5$ to $n+7$; or greater than $n+7$) (122-126). If, for discussion purposes, it is determined the detected xerographic density is in the range $n+2$ to $n+4$ (122), the following steps take place.

[0025] The image scanning process begins (128) and the system moves from an overall no operation (no-op) state into one where the output of the scanner is detected (130). One particular scanning technique is to determine if white ("0") or black ("1") pixels are encountered. When the step of checking the scan output (130) determines that a black pixel ("1") is encountered, the bit pattern which is being investigated is compared to stored templates to determine whether a template exists with a bit pattern matching the scanned bit pattern (132). When a template is found which matches the scanned image bit pattern, that template ---which will result in an output print having the nominal bit density value--- is selected (134), and replaces the existing scanned image bit pattern (136). It is next determined whether the scanning operation is complete (138), and if it is determined such scanning is complete, the process ends and the bitmapped image (with at least a portion of its bit pattern replaced) is forwarded for raster output scanning (e.g. ROS 20") (140). When the scanning process is not complete the process moves to step

128, and steps 128-138 are repeated.

[0026] On the other hand, as long as white pixels ("0") are encountered (130), then a no-operation state is maintained and the system transfers to step (140). If scanning is not determined to be complete, the system moves to block (128) and repeats steps (128-138).

[0027] With the actual xerographic density in the range of $n+5$ to $n+7$ (124), steps (142-152) are undertaken in a manner similar to steps (128-140). Also, a finding that xerographic density is greater than $n+7$ (126), means the difference between the predetermined desired bit density value and the actual xerographic density value is too large to be corrected, and a service call signal is activated (156).

[0028] In the foregoing embodiment, the templates stored in template storage 100 would be configured in a storage arrangement wherein all images which correct xerographic density values in the range $n+2$ to $n+4$ are in a separate area from images which correct xerographic density values found to be within the range of $n+5$ to $n+7$. In other words, when steps (132) or (146) are undertaken, the system will be looking at image patterns which are in a set of templates known to provide a proper adjustment to bring the density value of the image to be printed into a nominal range.

[0029] It is appreciated that other approaches for the template scanning techniques are available. For instance, turning to Figure 6 a second approach is depicted. Under this process, steps (160-170) are substantially identical to steps (110-120) of Figure 7. However, in step (162), when it is determined xerographic density values are outside the nominal range, the process passes to step (171) to determine if the xerographic density value is greater than $n+7$, a service request signal is generated (173). On the other hand, when the xerographic density value is outside the nominal range but not greater than $n+7$ the system moves to scanning step (172). Thereafter, a determination is made as to whether a certain pattern or state is encountered (e.g. if a black pixel ("1") is encountered) (174). The process then determines whether the template storage includes images which match the detected pattern (176). In this case, for instance, if the image pattern is for a "L" a determination is made as to whether the template storage includes "L" bit patterns. There may be a plurality of "L" bit patterns within the template storage each which may be appropriate for different density values. All of the "L" patterns are located within an "L" template set. In step (178), the detected xerographic density value which is outside the nominal range is compared with the "L" template set to determine the "L" bit-pattern which should be used to ensure the output image will be within a desired density range. If the scanning is complete (184) the image is moved to ROS (186), if not steps (172-184) are repeated.

[0030] In this embodiment, the template storage is configured where a group of templates matching a particular image, but having different correction ratios are

grouped together.

[0031] It is to be appreciated the foregoing is simply two embodiments which could occur within template matching module 40. Other specific scenarios may be contemplated for processing. However, the essential concept of using the xerographic density values to alter the binary image data is an outcome of each of the different embodiments.

[0032] Figure 7 further illustrates the template storage concepts previously discussed. A template set A will include all image patterns which will correct for xerographic density values within an $n-5$ to $n-7$ range; a template set B stores all image patterns which correct for an $n-2$ to $n-4$ xerographic density range; template set C includes images which correct for all xerographic density values in a range of $n+2$ to $n+4$; and template set D groups all the image patterns which correct for the xerographic density value range of $n+5$ to $n+7$. Thus, in connection with Figure 5, once the range of the xerographic density is determined, the search for an appropriate template will be within a template set corresponding to that range.

[0033] It will be noticed that there are no image patterns associated with the nominal range ($n-1$ to $n+1$) or to image ranges which are less than $n-7$ or greater than $n+7$.

[0034] As an alternative to the template storage configuration of Figure 7, Figure 8 illustrates a configuration more in line with the discussion of Figure 6. In this storage all templates for a particular image bit pattern (i.e. for example the image pattern "L") are within a template set irrespective of the ranges of which they may correct. Therefore, under the operation of Figure 6, a search will first be made for a bit pattern (i.e. "L"), then a comparison will be made between the patterns within this group to determine whether template 1 which corrects for $n-5$ to $n-7$; template 2 which corrects for $n-2$ to $n-4$; template 3 which corrects for a range of $n+2$ to $n+4$; or template 4 which corrects for a range of $n+5$ to $n+7$ is selected.

[0035] The foregoing is a generalized example which intends to show the concept of providing different storage configurations which each result in the desired outcome. The selection of the appropriate storage and processing technique will be dependant in part upon the machines which the present invention will be incorporated with and the operating specifications.

[0036] Returning attention to Figure 4, once bit-mapped scanned image 158 (either in an unaltered form from image 18---when the xerographic density value has been found to be within an appropriate nominal range---; or with altered bit patterns ---due to readings of the xerographic density values outside the nominal range---) has been fully scanned and forwarded to ROS 20, a photoreceptor image (i.e. Image 2) is formed on photoreceptor 92.

[0037] The preceding operation will be undertaken for each color separation (i.e. cyan, magenta, yellow

and black) of an image to be printed. As an alternative, a single average reading may be used for the entire image.

[0038] It is to be appreciated that the present invention also anticipates being used when the printing machine output is operating at a less than nominal output (e.g. $n-7$ to $n-5$; $n-3$ to $n-1$; etc.). Under these conditions the general processes described will be equally applicable.

[0039] It is noted that the bitmap scanner arrangement 98 may be implemented in a variety of known scanning procedures. One well known example is the use of a sliding window operation which has been described generally above. Material incorporated herein by reference provide more specific details to such operation. It is worth noting however, that in the window sliding technique, such as anticipated for bitmap scanner arrangement 98, an appropriately sized window (i.e. 5×5 , 9×9 , etc.) is used. When it is determined during this scanning procedure that the bit density value is outside of the nominally accepted amount, the template matching procedure is instituted within the windowed area. Although it may be envisioned that the changes to the binary image information may occur outside the windowed area. Also, while uniform square type scanning windows are commonly used, other shaped scanning areas may also be implemented with the present invention.

[0040] Figure 9 illustrates a selected template 190 with a pixel pattern which will replace an image pixel pattern 192 being scanned, for a printing machine which is running too "high." In this example, template 190 will have a smaller number of pixels in an "on" ("1") state, than pixel pattern 192. This is done in order to decrease the amount of toner output since the detected xerographic density is providing more toner than would be expected for the predetermined nominal density value. This example shows only a small portion (i.e. a single scan line section) of these bit patterns, normally stacks of templates are used to account for the various aspects of the image being altered in order to make correct assessments of the image.

[0041] What is occurring in a situation where the actual xerographic density values are greater or less than the nominal range ($n-1$ to $n+1$) is an indication that the xerographic process is providing more or less toner than a predetermined desired amount. Thus, in essence the present invention masks the fact that the xerographic system is not maintaining its pre-calibrated range. Therefore, at some point (i.e., greater than $n+7$ or less than $n-7$) a signal will be sent to the control system of the printing machine to indicate that it is necessary to repair the printer. In other words, the present invention does not actually correct the printing machine. Rather, it provides a template matching procedure to correct errors based on the state of the print engine (xerographic). More particularly, when the xerographic operation changes, the present invention institutes tem-

plate matching operations to mask this failure in the machine.

[0042] Thus, the present invention obtains knowledge of an analog device (xerographics) and uses that knowledge to change the digital image in real-time thereby yielding a different density print than would be obtained otherwise.

[0043] Figure 4 showed a series of test patches 90a-90n for a CMYK output. In this embodiment, the density testing is for an average of the entire page (per color separation) that is to be printed. However, as shown in Figure 10, by appropriate placement of test patches and the use of multiple bit density detectors, a more refined interpretation of density values can be obtained, and used for a more refined correction of the scanned images.

[0044] For example, the density value of cyan patch 194a is determined to have a xerographic density value of $n+6$ at edge X of photoreceptor 92; cyan patch 194b at a center portion Y is found to be within the nominal range ($n-1$ to $n+1$); and cyan patch 194c at edge Z is found to be $n-2$. Based on these findings, the system can implement a first template matching procedure when cyan pixels at edge X of photoreceptor 92 are scanned and a separate processing (i.e. using the different xerographic density value information) when cyan pixels at edge Z of photoreceptor 92 are scanned. The templates for each of these bit pattern replacements will therefore have different correction values. At the same time when pixels in the middle of the image are scanned, there will be a "no-op" situation since cyan test patch 194b was determined to be in the nominal bit density range. This arrangement allows for a more refined control for areas smaller than a single image.

[0045] The discussed concept of scanning an image to obtain information in accordance with the present invention is well known and can be accomplished in a number of ways. One way cited in the present application is with a window scanning. The scanning data used in conjunction with the xerographic density values to determine whether a template-matching operation is necessary. The concepts of image scanning and template matching are known in the art.

[0046] It is noted that once the detected xerographic density value is out of the predetermined acceptable range, the template-matching operation will be constantly applied.

[0047] Under a CMYK color scheme, with an understanding that there are four separations and five states of "density", and further with 100 pixel area coverage and 10 positions on a dot that are changeable, it can be estimated that there may be approximately 20,000 templates per dot. It is noted that the window which is used in the scanning operation should be of a significant enough size so it is possible for the scanning operation to view an entire "dot."

[0048] As previously discussed, it will also normally be necessary to have a stack of templates for each

scanned area as it will be important to recognize each gray level being investigated. Essentially, the "dot" has various states that the templates must be able to recognize each area of coverage. Therefore a stack of templates per dot investigation results in improved efficiency of the present invention.

[0049] While template matching has been shown to be one manner of adjusting a binary image due to changes in density, a more general aspect of the present invention is in the concept of changing binary image values based on analog-sensed outputs. In particular, the present invention recognizes that knowledge regarding an analog device is obtained, and that knowledge is used to change a digital image in real-time. Therefore while template matching is a process which can be easily conformed to the present invention, it is also to be recognized that other forms of changing the binary image based on these analog outputs may also be practical. For example, instead of templates, other look-up tables or calculations may also be used.

[0050] Further, the described apparatus and method is useable in any direct digital imaging system, including but not limited to Liquid Ink, Elcography, Ink Jet, Thermal Transfer, and Dye Diffusion, among others. Particularly, the apparatus and method includes applying template-based corrections to a latent digital image based on feedback from a current process state.

[0051] The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Claims

Thus, having described the preferred embodiments, the invention is now claimed to be:

1. An apparatus for maintaining image quality in a printing systems comprising:

- a process state detector which detects a process state of the printing system;
- a template matching device configured to receive data from the process state detector regarding the process state of the printing system;
- an image scanner for scanning a binary bit-mapped image; and
- a template storage which stores a plurality of predefined templates of bit-mapped patterns, wherein the data from the process state detector is used to determine whether at least a portion of the binary bit-mapped image is to be replaced by at least one of the plurality of pre-

- defined templates through operation of the template matching device.

2. The apparatus according to claim 1 wherein the data from the process state detector is collected based on analog signals, and the binary bit-mapped image is configured in accordance with digital signals, such that output analog signals of the printing system are used to alter the binary bit-mapped digital image.
3. The apparatus according to claim 1 wherein the process state being detected is that of a density of a marking material located on a surface, and the surface is at least one of paper and a photoreceptor, and the marking material is located on at least one of paper and the photoreceptor.

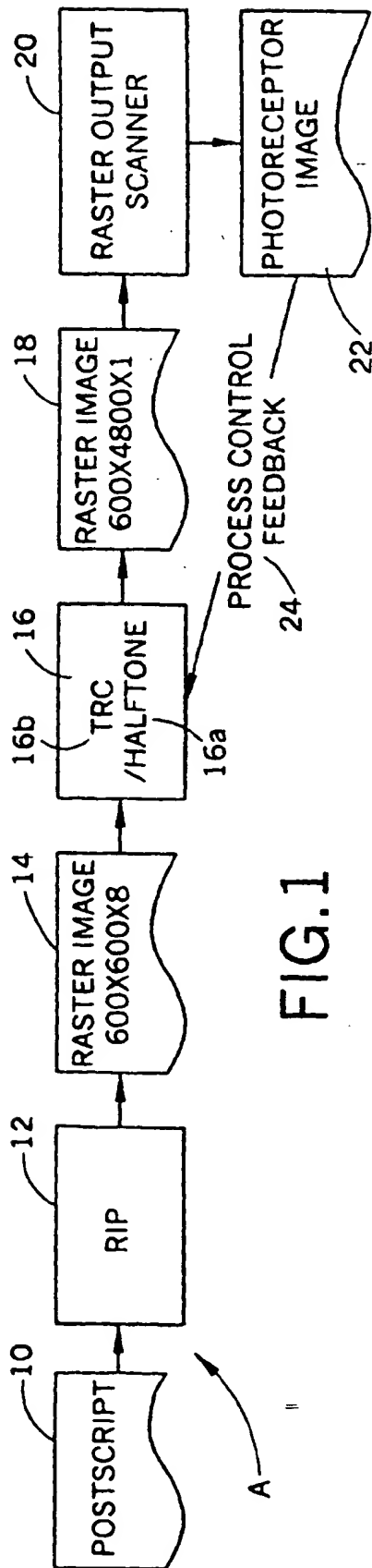


FIG. 1

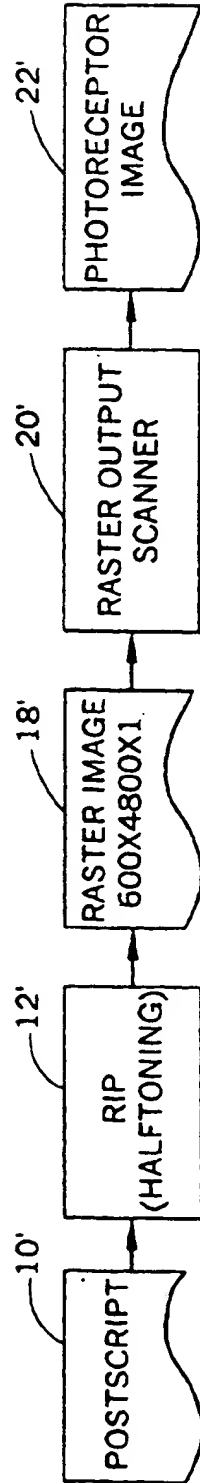


FIG. 2

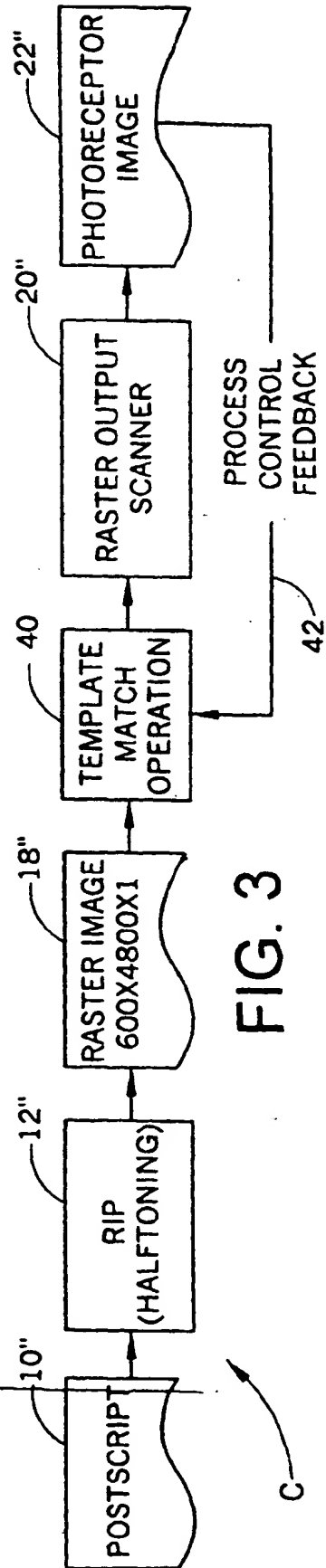
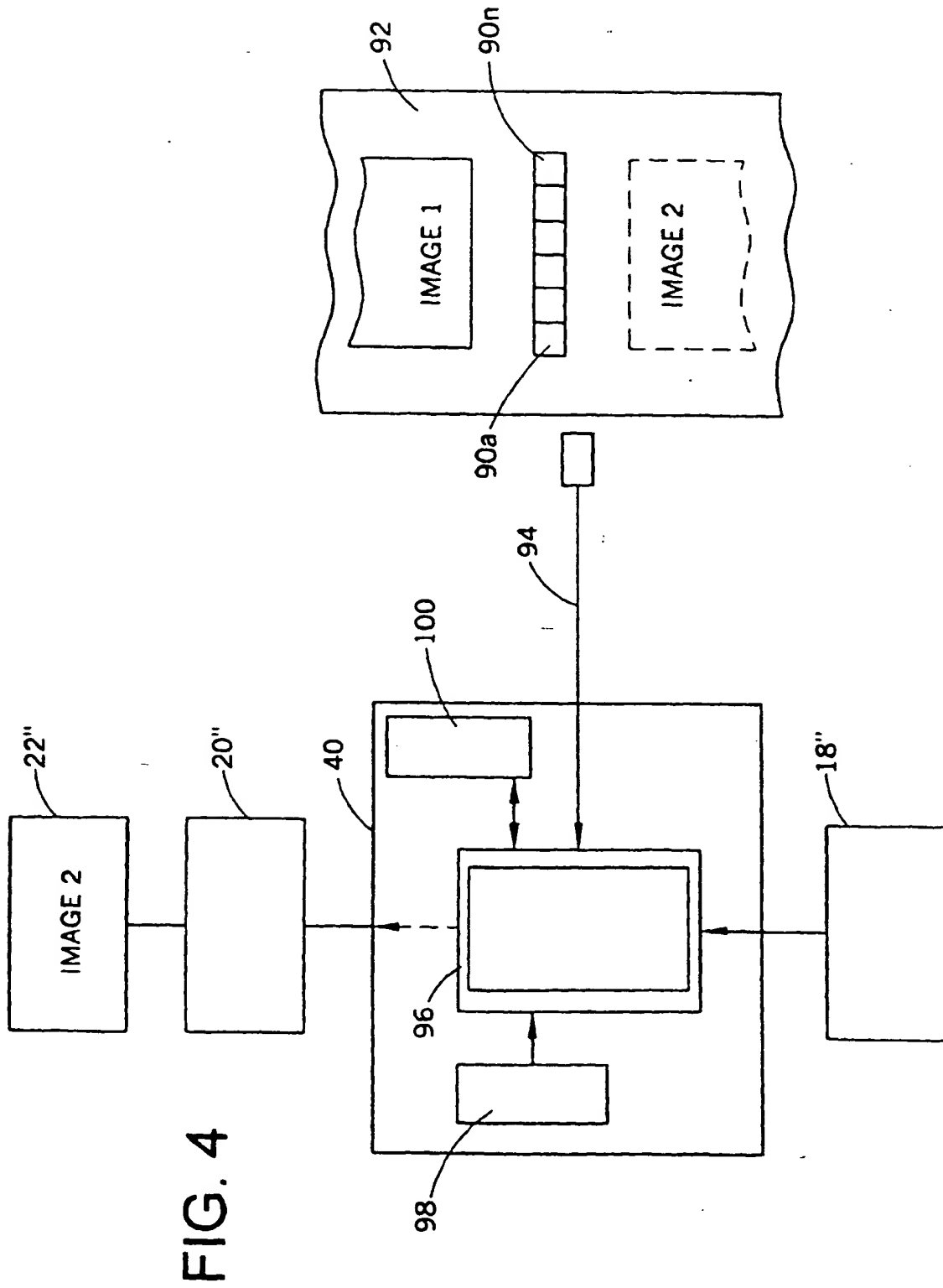


FIG. 3



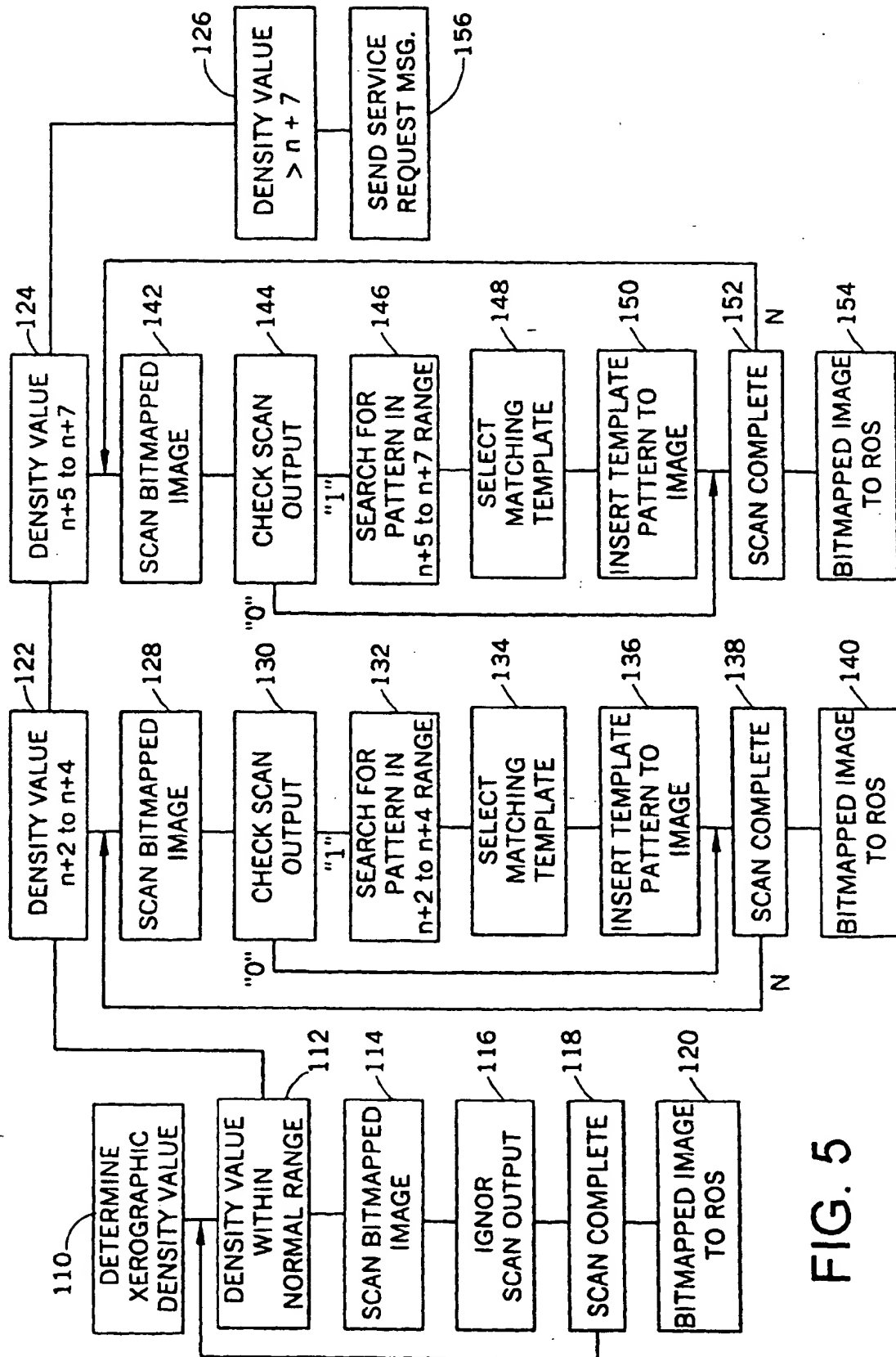


FIG. 5

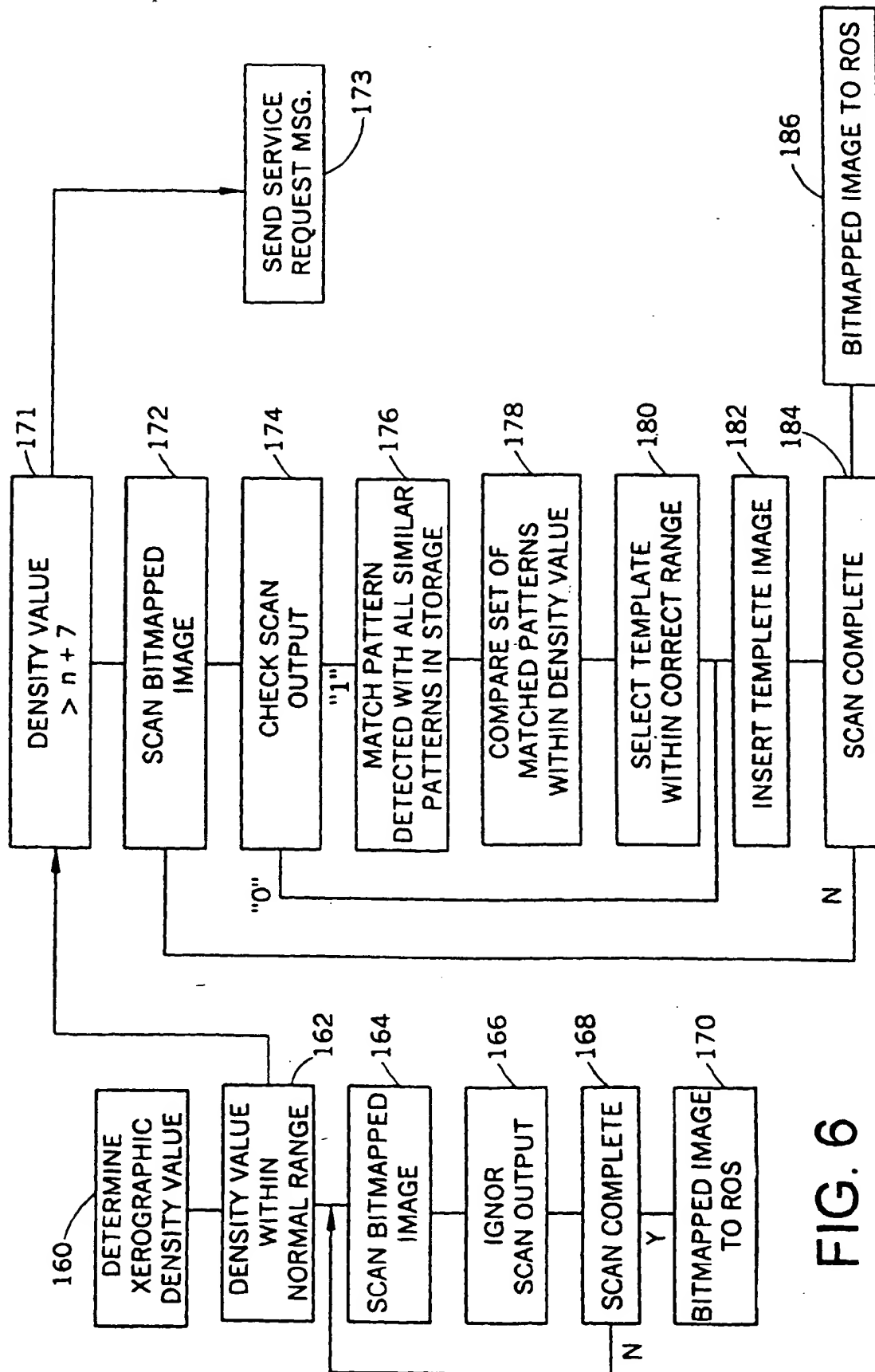
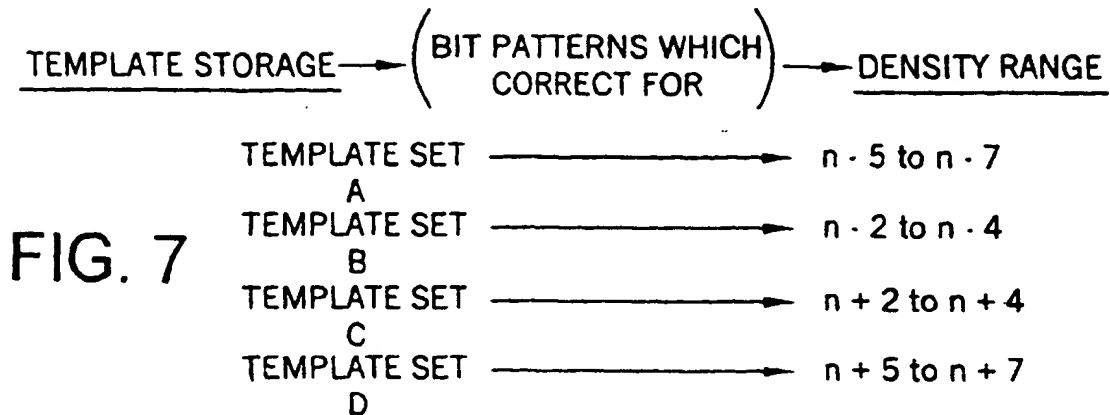


FIG. 6



TEMPLATE STORAGE
TEMPLATE SET FOR ALL
"L" BIT PATTERNS

L
⋮
L
⋮
L

FIG. 8

FIG. 9

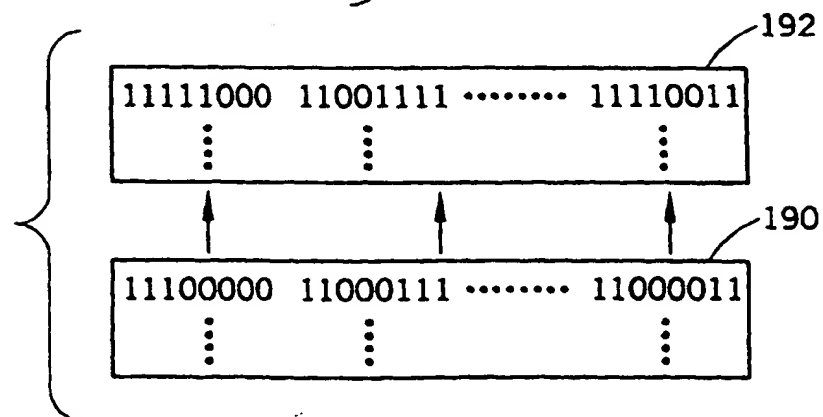
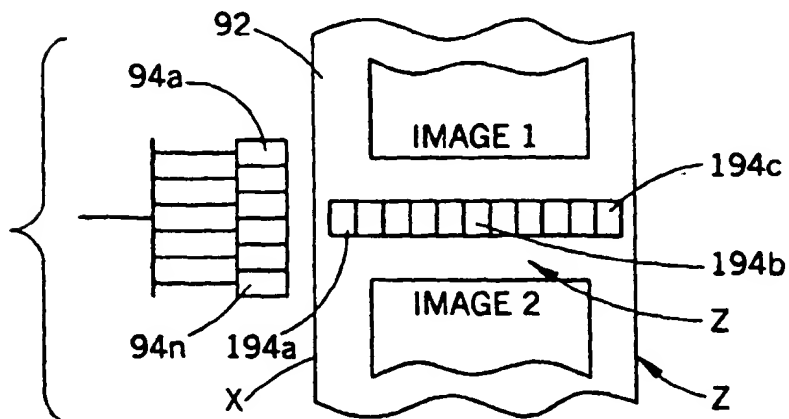


FIG. 10



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 1037-020W001	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 02/ 23695	International filing date (day/month/year) 24/07/2002	(Earliest) Priority Date (day/month/year)
Applicant KODAK POLYCHROME GRAPHICS		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

10

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 02/23695

Box III TEXT OF THE ABSTRACT (Continuation of Item 5 of the first sheet)

The invention provides techniques for thinning halftone dots in a halftone dot bit map. A bit map filter may be used to thin the dots. A target glyph is passed over the bit map. If any subsets of bits within the bit map match the target glyph, the subsets of bits can be replaced with bits defined by a thinned glyph. In this manner, the ink of a halftone print can be reduced in a manner that enhances the visual appearance of the print.

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 02/23695

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N1/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 014 296 A (XEROX CORP) 28 June 2000 (2000-06-28) paragraph '0040! paragraph '0016! ---	1-6, 9, 10
X	FR 2 771 833 A (VARIS CORP) 4 June 1999 (1999-06-04) abstract; figure 4 page 14, line 11 - line 21 ---	1, 2, 9, 10
A	US 5 353 387 A (PETSCHIK BENNO ET AL) 4 October 1994 (1994-10-04) column 4, line 52 - column 5, line 60; figure 5 ---	1-3
A	US 5 706 414 A (PRITCHARD THOMAS B) 6 January 1998 (1998-01-06) abstract; claim 6; figures 1-7 --- -/--	4, 5

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

8 document member of the same patent family

Date of the actual completion of the international search

8 November 2002

Date of mailing of the international search report

15/11/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx 31 651 epo nl.

Authorized officer

Kassou U

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 02/23695

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 580 376 A (XEROX CORP) 26 January 1994 (1994-01-26) -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 02/23695

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1014296	A	28-06-2000	US 6366362 B1	02-04-2002
			EP 1014296 A2	28-06-2000
			JP 2000190581 A	11-07-2000
FR 2771833	A	04-06-1999	FR 2771833 A1	04-06-1999
US 5353387	A	04-10-1994	WO 9204191 A1	19-03-1992
			DE 59104637 D1	23-03-1995
			EP 0548097 A1	30-06-1993
			JP 6500744 T	27-01-1994
US 5706414	A	06-01-1998	DE 69420225 D1	30-09-1999
			DE 69420225 T2	09-12-1999
			EP 0650140 A2	26-04-1995
			JP 7236057 A	05-09-1995
EP 0580376	A	26-01-1994	US 5515479 A	07-05-1996
			BR 9302940 A	22-02-1994
			CA 2100886 A1	24-01-1994
			DE 69326645 D1	11-11-1999
			DE 69326645 T2	20-04-2000
			EP 0580376 A1	26-01-1994
			JP 6191144 A	12-07-1994
			MX 9303440 A1	31-03-1994